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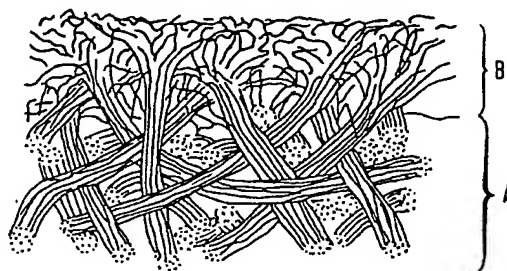
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54 **Ultrafine fiber entangled sheet and method of producing the same.**

57 An entangled non-woven fabric having a fiber structure which comprises a portion (A) in which ultrafine fiber bundles consisting of ultrafine fibers of a size of not greater than about 0.5 denier are entangled with one another and a portion (B) in which ultrafine fibers to fine bundles of ultrafine fibers branch from the ultrafine fiber bundles and are entangled with one another, and in which portions (A) and (B) are nonuniformly distributed in the direction of fabric thickness. The product of this invention has high flexibility as well as good shape retention.

The invention also relates to a grained sheet having on at least one of its surfaces a grain formed by a fiber structure composed of ultrafine fibers to fine bundles of ultrafine fibers and having a distance between the fiber entangling points of not greater than about 200 microns, and a resin in the gap portions of the fiber structure. The grained sheet of the invention has high flexibility resistance, shearing fatigue resistance and scratch and scuff resistance.



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ULTRAFINE FIBER ENTANGLED SHEET  
AND METHOD OF PRODUCING THE SAME

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This invention relates to a novel ultrafine fiber entangled sheet and a method for the production thereof. More particularly, the present invention relates to a novel entangled non-woven fabric having a fiber structure which includes a layer comprised of ultrafine fiber bundles that are en-  
25 tangled with one another and a layer comprised of ultrafine fibers to fine bundles of ultrafine fibers wherein both layers are nonuniformly distributed in the direction of fabric thickness, and to a method of producing the entangled  
30 non-woven fabric. Further, the present invention relates to a novel grained sheet having a grain comprised of densely entangled ultrafine fibers to fine bundles of the ultrafine fibers and resin and to a method of producing the novel grained sheet.

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1 Typical examples of conventional non-woven fabrics include  
(1) non-woven fabric which is produced by webbing conven-  
tional staple fibers into a random web and then needle-  
punching the web, and (2) non-woven fabric as disclosed in  
5 Japanese Patent Publication No. 24699/1969 which has a  
fiber structure which consists principally of single fibers  
that are gathered and bundled, and in which the fiber  
bundles are entangled with one another while maintaining  
the bundle form. However, since fabric (1) has a fiber  
10 structure which is relatively thick and the fibers are  
individually three-dimensionally entangled with one  
another, the non-woven fabric has low flexibility and very  
poor tactile properties. Hence, the commercial value of  
this non-woven fabric has been considerably limited.  
15 Although fabric (2) has higher flexibility than fabric (1),  
non-woven fabric (2) has extremely low shape retention.

With regard to grained sheets, the grain of conventional  
synthetic leather consists of a porous or nonporous layer  
20 of resin, such as polyurethane elastomer, or of an integral  
laminate of the porous layer with the nonporous layer.  
However, synthetic leather having such a grain has various  
drawbacks such as low feel of integration, a very undesir-  
able rubber-like feel, low crumple resistance, excessively  
25 uniform and shallow surface luster, and so forth.

To eliminate these drawbacks, various proposals have been  
made. These proposals include:

- 30 (1) Various fillers, such as fine particles, are added in  
forming the grain.
- (2) Ultrafine fibers are arranged along the surface and  
combined with a porous material to form the grain  
(Japanese Patent Publication No. 40921/1974).
- (3) A surface fluff fiber and resin are combined to form  
35 the grain.
- (4) The surface fibers are melted or dissolved so as to  
locally bond the fibers and form the grain.

1 However, method (1) has drawbacks in that the flexibility  
is reduced and the grain luster of the product is di-  
minished by addition of the fillers. Since the product  
obtained by method (2) has grain fiber structure in which  
5 the ultrafine fibers are arranged along the surface in  
bundle form, the surface fluffs and peeling develops along  
the surface of the arrangement of the fiber bundles to  
cause "loose grain" if the sheet or leather is strongly  
crumpled or shearing stress is repeatedly applied to the  
10 sheet. Where the crumpling, or repeated shearing stress  
continues, cracks eventually occur on the surface. More-  
over, fine unevenness occurs on the surface along the  
bundles of the ultrafine fibers and degrades the surface  
appearance. The products obtained by methods (3) or (4)  
15 have drawbacks in that the surface cracks relatively  
easily, severely degrading the appearance, when the sheet  
is repeatedly bent or shearing stress is repeatedly applied  
to the sheet.

20 It is an object of the present invention to provide a  
non-woven fabric which eliminates the problems encountered  
with the prior art products described above and which has  
high flexibility as well as high shape retention.

25 It is another object of the present invention to provide a  
method of producing a non-woven fabric which has high  
flexibility as well as high shape retention.

It is still another object of the present invention to  
30 provide a grained sheet which is free from the problems  
encountered with the conventional synthetic leather de-  
scribed above and has particularly high flexibility re-  
sistance, crumple resistance, shearing fatigue resistance  
and scratch and scuff resistance.

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It is a further object of the present invention to provide  
a method of producing a grained sheet which has particular-

1 ly high flexibility resistance, crumple resistance, shear-  
ing fatigue resistance and scratch and scuff resistance.

These objects are accomplished by the present invention as  
5 described hereinbelow.

First, the present invention provides an entangled non-  
woven fabric which includes a portion (A) comprised of  
ultrafine fiber bundles of ultrafine fibers having a size  
10 not greater than about 0.5 denier which bundles are en-  
tangled with one another, and a portion (B) comprised of  
ultrafine fibers to fine bundles of ultrafine fibers  
branching from the ultrafine fiber bundles which ultrafine  
fibers and fine bundles of ultrafine fibers are entangled  
15 with one another, and in which both portions (A) and (B)  
are nonuniformly distributed in the direction of fabric  
thickness. The present invention also provides a method of  
producing such an entangled non-woven fabric.

20 Second, the present invention provides a grained sheet  
having on at least one of its surfaces a grain formed by a  
composite structure comprised of a fiber structure composed  
of ultrafine fibers to fine bundles of ultrafine fibers and  
having a distance between the fiber entangling points not  
25 greater than about 200 microns, and a resin in the gap  
portions of the fiber structure. The present invention also  
provides a method of producing such a grained sheet.

Figure 1 is a sectional view of a non-woven fabric in  
30 accordance with the present invention;  
Figures 2(a) to 2(g) are various embodiments of the layers  
of the non-woven fabric in accordance with the present  
invention;  
Figure 3 is a schematic view of entangled constituent  
35 fibers of the grain on the surface side of the grained  
sheet of the present invention; and  
Figures 4(a) to 4(o) are schematic sectional views showing

1 typical examples of fibers which may be used to form the  
ultrafine fibers employed in the present invention.

In the following the invention will be described in detail  
5 with respect to preferred embodiments thereof.

The term "ultrafine fiber bundle" as used herein denotes  
fiber bundle in which a plurality of fibers in staple or  
filament form are arranged in parallel with one another.

10 The fibers may be all of the same type or a combination of  
fiber types may be used. The entangled non-woven fabric in  
accordance with the present invention has a fiber structure  
including a portion (A) in which the ultrafine fibers are  
three-dimensionally entangled with one another in bundle  
15 form without substantially collapsing the state of arrange-  
ment described above and a portion (B) in which ultrafine  
fibers to fine bundles of ultrafine fibers branch from the  
ultrafine fiber bundles of portion (A), the fine bundles of  
ultrafine fibers being thinner than the fiber bundles of  
20 portion (A), are densely entangled with one another, and  
portions (A) and (B) are nonuniformly distributed in the  
direction of fabric thickness. The fiber that forms the  
entangled non-woven fabric of the present invention has a  
fiber structure such that one ultrafine fiber is one of  
25 fibers constituting a bundle at some portions of the bundle  
and branches from the bundle at the other portions of the  
bundle. Therefore, the ultrafine fiber bundle and the  
fibers branched from the bundle are not independent.

30 An entangled non-woven fabric whose entire portion consists  
of portion (A) is formed by means of the entanglement of  
the fiber bundles with one another. Accordingly, since the  
entanglement is not dense and can be easily loosened, the  
non-woven fabric is extremely likely to undergo deformation  
35 and it is difficult for the non-woven fabric to retain its  
shape particularly in a wet or hydrous state.

1 In an entangled non-woven fabric whose entire portion  
consists of portion (B), on the other hand, the entangle-  
ment of the fibers of the non-woven fabric as a whole is  
very dense and mutual restriction of fiber movement occurs  
5 so that the non-woven fabric has insufficient flexibility.

The objects of the present invention can be accomplished  
only when portions (A) and (B) are nonuniformly distributed  
in the direction of the thickness of the fabric. It is  
10 particularly preferred that portion (B) be nonuniformly  
distributed along the surface portion. Such a non-woven  
fabric has less fraying of the surface fibers and resists  
pilling. If the non-woven fabric has a fiber structure in  
which the ultrafine fibers constituting portions (A) and  
15 (B) are substantially continuous and the degree of branch-  
ing of the fibers in the proximity of the boundary between  
the portions changes continuously, the non-woven fabric has  
integral hand characteristics such as flexibility and  
suppleness and portions (A) and (B) do not peel from one  
20 another.

Figure 1 illustrates an embodiment of the entangled non-  
woven fabric in accordance with the present invention. In  
Figure 1, A denotes the portion in which ultrafine fiber  
25 bundles are entangled with one another and B denotes the  
portion in which ultrafine fibers and fine bundles of  
ultrafine fibers branch from the ultrafine fiber bundles  
and are entangled with one another. Figures 2(a) to 2(g)  
illustrate embodiments in which portions A and B are  
30 nonuniformly distributed in the direction of thickness.

The grained sheet in accordance with the present invention  
is a composite structure whose grain is comprised of  
ultrafine fibers to fine bundles of ultrafine fibers and of  
35 a resin present in the gap portions of the fibers and the  
fine bundles. The fundamental structure is one in which  
ultrafine fibers and fine bundles of ultrafine fibers are

1 densely entangled with one another. Only this combination  
can provide a grained sheet having good hand character-  
istics such as flexibility and suppleness, smooth surface,  
high flexibility resistance, shearing fatigue resistance  
5 and scratch and scuff resistance.

It is required that the fiber structure in the grain of the  
grained sheet of the present invention be such that the  
ultrafine fibers and the fine bundles of the ultrafine  
10 fibers are densely entangled with one another. In other  
words, it is necessary that the entanglement density of the  
fibers be high. One of the methods of measuring the en-  
tanglement density of the fibers is to measure the distance  
between the fiber entanglement points. A short distance  
15 between points of entanglement evidences a high density of  
entanglement.

The distance between the fiber entanglement points is  
measured in the following manner. Figure 3 is an enlarged  
20 schematic view of the constituent fibers in the grain when  
viewed from the surface side. It will be assumed that the  
constituent fibers are  $f_1, f_2, f_3, \dots$ , the point at  
which two arbitrary fibers  $f_1$  and  $f_2$  among them are  
entangled with each other is  $a_1$  and the point at which  
25 the upper fiber  $f_2$  is entangled with another fiber with  
the fiber  $f_2$  being the lower fiber is  $a_2$  (the entangle-  
ment point between  $f_2$  and  $f_3$ ). Similarly, the entangle-  
ment points  $a_3, a_4, a_5, \dots$  are determined. The  
linear distances  $a_1a_2, a_2a_3, a_3a_4, a_4a_5, a_5a_6, a_6a_7,$   
30  $a_7a_8, a_8a_9, a_9a_6, \dots$  measured  
along the surface are the distance between the fiber  
entangling points.

In the present invention, the fibers of the grain must have  
35 an entanglement density of not greater than about 200  
microns as measured by this method. In fiber structures  
where the entanglement density is greater than about 200



1 microns, such as in those fiber structures in which the  
entanglement of the fibers is effected only by needle  
punching, in which ultrafine fibers or bundles are merely  
arranged along the surface or, in which thickly raised  
5 ultrafine fibers or bundles are laid down on the surface of  
a substrate to form the grain, little or no entanglement of  
the fibers occurs. When friction, crumpling and shearing  
stress are repeatedly applied to such fabrics the surface  
is likely to fluff unsightly or to develop cracks. To  
10 eliminate these problems, the distance between the fiber  
entangling points must not be greater than 200 microns.  
More favorable results are obtainable when the distance is  
not greater than about 100 microns.

15 There are no specific requirements for the structure of the  
layer below the grain of the grained sheet in accordance  
with the present invention and this layer may be suitably  
constructed in accordance with the intended application.  
However, the lower layer preferably has the following  
20 structure. The lower layer of the grained sheet preferably  
has a fiber structure in which ultrafine fiber bundles are  
entangled with one another, ultrafine fibers and the fine  
bundles of ultrafine fibers of the grain are formed as the  
ultrafine fiber bundles of the lower layer branch and are  
25 densely entangled with one another, the fibers in the grain  
are substantially continuous with the fibers in the lower  
layer and, moreover, the degree of branching of the fibers  
continuously changes at the boundary between both layers.  
Such a fiber structure provides a sheet having integral  
30 hand characteristics and prevents peeling of the grain from  
the lower layer. In this instance, it is not necessary that  
the size of the fine bundles of ultrafine fibers of the  
grain be all the same. If the size of the bundles of the  
ultrafine fibers of the grain is less than that of the  
35 ultrafine fibers of the lower layer, or if the number of  
fibers contained in one bundle of the grain is smaller than

1 that of the lower layer, unevenness does not easily occur  
on the surface of the sheet.

In the conventional grained sheet where the substrate or  
5 base consists solely of a non-woven fabric, such as is  
formed solely by needle punching, as the substrate, the  
sheet is easily extensible upon application of tensional  
forces and is non-elastically deformed. With such a sub-  
strate, a resin must be applied to the substrate to prevent  
10 deformation of the grained sheet.

In contrast, the grained sheet of the present invention,  
having a fiber structure in which the ultrafine fibers and  
the fine bundles of the ultrafine fibers of the grain are  
15 densely entangled with one another, is not seriously  
deformed under application of in-use tensional forces and  
has good shape retention even when resin is not applied to  
the lower layer. This is also one of the most character-  
izing features of the grained sheet of the present in-  
20 vention. Needless to say, resin such as polyurethane  
elastomer may be applied to the lower layer and deposition  
quantity of the resin varies depending upon the application  
of the sheet. For example, when the sheet is to be used for  
apparel, the resin deposition quantity is preferably 0 to  
25 80 parts by weight based on the weight of the fibers.

Resins which may be used for the grained sheet are syn-  
thetic or natural polymer resins such as polyamide,  
polyester, polyvinyl chloride, polyacrylate copolymers,  
30 polyurethane, neoprene, styrene butadiene copolymers,  
acrylonitrile/butadiene copolymers, polyamino acids,  
polyamino acid/polyurethane copolymers, silicone resins and  
the like. Mixtures of two or more resins may also be used.  
If necessary, additives such as plasticizers, fillers,  
35 stabilizers, pigments, dyes, cross-linking agents, and the  
like may be further added. Polyurethane elastomeric resin,  
either alone or mixed with other resins or additives, is

- 1 preferably used because it provides a grain having particularly good hand characteristics such as flexibility and suppleness, good touch and high flexibility resistance.
- 5 The deposition structure of the resin in the grain is dependent on the intended application. Where flexibility and soft touch are required such as in apparel, preferred structures are those in which the resin is applied in a progressively increasing amount towards the surface of the
- 10 grain. The resin deposition quantity is the greatest in an extremely thin layer on the outermost surface of the grain with little or no resin at other portions. The resin at the surface portion is non-porous, whereas the portion below the surface portion is porous. Where high scratch and scuff
- 15 resistance are particularly required, a preferred fiber structure is one where the resin is packed substantially fully into the gap portions of the grain without leaving any gaps intact. The grained sheet in accordance with the present invention includes, of course, one in which the
- 20 outermost surface of the grain consists of a thin resin layer of up to about 30 microns of a resin such as a polyurethane elastomer which is integrated with the other portions.
- 25 As the ultrafine fibers to be used in the present invention, there may be mentioned those which are produced by various direct methods, such as super-draw spinning, jet spinning using a gas stream, and so forth. In accordance with these methods, however, spinning would become unstable
- 30 and difficult if the fiber size becomes too fine. For these reasons, it is preferred to employ the following types of fibers which are formable into ultrafine fibers and to modify them into ultrafine fibers at a suitable stage of the production process. Examples of such ultrafine fiber
- 35 formable fibers include those having a chrysanthemum-like cross-section in which one component is radially interposed between other components, multi-layered bicomponent type

1 fibers, multi-layered bicomponent type fibers having a  
doughnut-like cross-section, mixed spun fibers obtained by  
mixing and spinning at least two components, islands-in-  
a-sea type fibers which have a fiber structure in which a  
5 plurality of ultrafine fibers that are continuous in the  
direction of the fiber axis are arranged and aggregated and  
are bonded together by other components to form a fiber,  
specific islands-in-a-sea fibers which have a fiber struc-  
ture in which a plurality of extra-ultrafine fibers are  
10 arranged and aggregated and are bonded together by other  
components to form an ultrafine fiber and a plurality of  
these ultrafine fibers are arranged and aggregated and are  
bonded together by other components to form a fiber, and so  
forth. Two or more of these fibers may be mixed or com-  
15 bined.

It is preferable that ultrafine fiber formable fibers  
have a fiber structure in which a plurality of cores are  
at least partially bonded by other binding components,  
20 because they provide relatively readily ultrafine fibers by  
applying physical or chemical action to them or by removing  
only the binding components.

Figures 4(a) to 4(o) show examples of the ultrafine fiber  
25 formable fibers which may be used to obtain the ultrafine  
fibers. In Figures 4(a) to 4(o), reference numerals 1 and  
1' represent ultrafine fibers and reference numerals 2 and  
2' represent binding components. The ultrafine fibers may  
be composite fibers consisting of similar polymer materials  
30 in kind or different polymer materials in kind. Other types  
of fibers which may be used include crimped fibers, modi-  
fied cross-section fibers, hollow fibers, multi-hollow  
fibers and the like. Further, ultrafine fibers of different  
kinds may be mixed.

35

The size of the ultrafine fibers in the entangled non-woven  
fabric in accordance with the present invention must not be

1 greater than about 0.5 deniers. If the denier is greater  
than 0.5, the stiffness of the fibers is so great that the  
resulting non-woven fabric has low flexibility and it is  
difficult to densely entangle the fibers.

5

The ultrafine fibers in the grain of the grained sheet of  
the present invention are preferably not greater than about  
0.2 denier. If the fibers are greater than 0.2 denier, the  
fiber stiffness is so great that the grain loses flex-  
10 ibility, the surface develops unsightly creases and cracks,  
surface unevenness is likely to occur upon crumpling of the  
sheet and it is difficult to form a dense and flexible  
grain. Only with ultrafine fibers having a size not greater  
than about 0.2 denier, more preferably, not greater than  
15 about 0.05 denier, can a leather-like sheet be obtained  
which has a grain fiber structure in which the fibers are  
densely entangled with one another, which has excellent  
smoothness, which is soft and which is resistant to de-  
velopment of cracks. Multiple-component ultrafine fiber  
20 formable fibers, which provide fiber bundles principally  
comprised of ultrafine fibers having a denier not greater  
than about 0.2, preferably not greater than about 0.05  
denier, and in which at least one component may be dis-  
solved and removed, are preferably employed. Such fibers  
25 can provide a grained sheet having particularly excellent  
hand characteristics, such as flexibility and suppleness,  
and a smooth surface. Those fibers which have a specific  
fiber structure in which a plurality of extra-ultrafine  
fibers are arranged and aggregated and are bonded together  
30 by other components to form one ultrafine fiber (primary  
bundle) and a plurality of these ultrafine fibers are  
arranged and aggregated and are bonded together by other  
components to form one fiber (secondary bundle) can be  
fibrillated extremely finely and entangled densely when  
35 they are subjected to high speed fluid jet streams. Hence,  
such fibers provide a grained sheet having extremely soft  
and excellent touch.

1 The ultrafine fibers of the present invention consist of  
polymer material having fiber formability. Examples of the  
polymer material include polyamides, such as nylon 6, nylon  
66, nylon 12, copolymerized nylon, and the like; poly-  
5 esters, such as polyethylene terephthalate, polybutylene  
terephthalate, copolymerized polyethylene terephthalate,  
copolymerized polybutylene terephthalate, and the like;  
polyolefins, such as polyethylene, polypropylene, and the  
like; polyurethane; polyacrylonitrile; vinyl polymers; and  
10 so forth. Examples of the binding component of the ultra-  
fine fiber formable fibers, or the component which is to be  
dissolved for removal, include polystyrene, polyethylene,  
polypropylene, polyamide, polyurethane, copolymerized  
polyethylene terephthalate that can be easily dissolved in  
15 an alkaline solution, polyvinyl alcohol, copolymerized  
polyvinyl alcohol, styrene/acrylonitrile copolymers,  
copolymers of styrene with higher alcohol esters of acrylic  
acid and/or with hither alcohol esters of methacrylic acid,  
and the like.

20 From the aspect of fiber spinnability, as well as dissolv-  
ability for removal of the binding component, however,  
polystyrene, styrene/acrylonitrile copolymers, and co-  
polymers of styrene with higher alcohol esters of acrylic  
25 acid and/or with higher alcohol esters of methacrylic acid  
are preferably used. The copolymers of styrene with higher  
alcohol esters of acrylic acid and/or with higher alcohol  
esters of methacrylic acid are further preferably used  
because during drawing they provide a higher draw ratio and  
30 fibers having higher strength.

In order to easily fibrillate the ultrafine fiber formable  
fibers it is preferred to mix some amount of heterogeneous  
substance to the binding component before spinning. Such  
35 heterogeneous substance makes easy to break or remove the  
binding component by treating with high speed fluid jet  
streams. Thus the ultrafine fiber formable fibers are

1 fibrillated into ultrafine fibers or fine bundles of  
ultrafine fibers and densely entangled. Examples of the  
heterogeneous substances include polyalkyleneetherglycols,  
such a polyethyleneetherglycol, polypropyleneetherglycol ,  
5 polytetramethyleneetherglycol and the like; substituted  
polyalkyleneetherglycols such as methoxypolyethyleneether-  
glycol and the like; block or random copolymers such as  
block copolymer of ethyleneoxide and propyleneoxide, random  
copolymer of ethyleneoxide and propyleneoxide, and the  
10 like; alkyleneoxide additives of alcohols, acids or esters,  
such as ethyleneoxide additive of nonylphenol and the like;  
block copolymers of polyalkyleneetherglycols and other  
polymers, such as block polyetherester of polyethylene-  
etherglycol and various polyesters, block polyetheramide of  
15 polyethyleneetherglycol and various polyamides; polymers  
mentioned above as the binding component in combination  
with different polymer as the binding component; fine  
particles of inorganic compounds such as calcium carbonate,  
talc, silica, colloidal silica, clay, titanium oxide,  
20 carbon black and the like; mixtures thereof and so forth.

In view of spinnability and effect of fibrillation, organic  
polymers, especially polyaklyleneetherglycols are prefer-  
able. Among these, polyethyleneetherglycol is most effect-  
25 ive for fibrillation and dense entanglement. Certain amount  
of polyethyleneetherglycol helps breaking of a binding  
component while treating with the high speed fluid jet  
streams and makes it possible to remove the binding com-  
ponent without dissolving out by a solvent.

30

Preferable molecular weight range of polyalkyleneether-  
glycol is 5,000 to 600,000, especially, 5,000 to 100,000 in  
view of its melt viscosity.

35 Preferred amount of heterogeneous substance varies accord-  
ing to intended use. In case of polyalkyleneetherglycol,  
0.5 to 30 wt%, based on the total amount of binding com-

ponent, is preferable. 2 to 20 wt% is most preferable. If the amount is under 0.5 wt%, the fibrillation effect is inferior, and if the amount is over 30 wt%, fiber spinnability becomes worse.

5

There is no limitation, in particular, to the size of the ultrafine fiber formable fibers but the preferred size range is from about 0.5 to 10 denier in view of spinning stability and ease of sheet formation.

10

The method of producing the entangled non-woven fabric in accordance with the present invention comprises, for example, forming a web by use of fiber bundles which are obtained by bundling ultrafine fibers obtained in the manner described above and temporarily treating them with a binding component to retain the fibers in bundle form, or by use of filaments or staple fibers of ultrafine fiber formable fibers, then optionally needle-punching the resulting web to form an entangled structure and thereafter removing the binding component using a solvent which can dissolve only the binding component. Thereafter, the resulting entangled structure is treated with high speed fluid jet streams so as to branch the ultrafine fibers and the fine bundles of ultrafine fibers from the ultrafine fiber bundles and to simultaneously entangle the branching ultrafine fibers and the fine bundles of ultrafine fibers. A step of applying a paste, such as polyvinyl alcohol, to temporarily fix the non-woven fabric as a whole after the entangled structure is formed by needle-punching, and removing the paste after dissolution and removal of the binding component or simultaneously effecting the high speed fluid jet streams treatment with the removal of the paste, so as to prevent the collapse of the shape of the non-woven fabric at the time of dissolution and removal of the binding component may optionally be used in the process. The treatment with the high-speed fluid jet streams may be effected before the binding component is removed.



1 In some cases, branching of the fibers by treatment with  
the high speed fluid jet streams is not sufficiently  
effected because the ultrafine fibers are bonded together  
by the binding component. In such cases, branching can be  
5 accomplished extremely effectively by the following method.  
A polymer, such as polyethylene glycol, is added to the  
binding component for the ultrafine fibers or, alterna-  
tively, a substance that can degrade or plasticize the  
binding component is applied to the fiber sheet before the  
10 treatment with the high speed fluid jet streams.

Examples of a substance that can degrade or plasticize the  
binding component include degrading agents, solvents,  
plasticizers and surfactants for such a binding component.  
15 Any substance can be used which can cause cracks in the  
binding components, can change the binding component into a  
powder, can plasticize or degrade it and can thus reduce  
the collapse resistance of the binding component at the  
time of the treatment with the high speed fluid jet  
20 streams. For such surfactants, some esters or polyalkylene-  
etherglycols and carboxylic acids are useful. As poly-  
alkyleneetherglycol, polyethyleneetherglycol, poly-  
propyleneetherglycol, polytetramethyleneetherglycol and  
copolymer thereof are preferably used. As carboxylic acid,  
25 propionic acid, butyric acid, caproic acid, caprylic acid,  
lauric acid, myristic acid, palmitic acid, stearic acid,  
and the like, are preferably used.

In order to obtain the structure of the entangled non-woven  
30 fabric of the present invention, the apparent density of  
the non-woven fabric before the treatment with the high  
speed fluid jet streams is preferably from about 0.1 to  
0.6 g/cm<sup>3</sup>. If the apparent density is below about  
0.1 g/cm<sup>3</sup>, the fibers move easily and those pushed by the  
35 fluid jet streams penetrate through the non-woven fabric  
and intrude into the metal net on which the non-woven  
fabric is placed, so that severe unevenness appears on the

1 surface of the non-woven fabric. If the apparent density is  
above about  $0.6 \text{ g/cm}^3$ , the fluid jet streams are re-  
flected on the surface of the non-woven fabric and en-  
tanglement is not sufficiently accomplished.

5

The term "fluid" herein used denotes a liquid or a gas and,  
in some particular cases, may contain an extremely fine  
solid. Water is most desirable from the aspects of ease in  
handling, cost and the quantity of fluid collision energy.

10 Depending upon the intended application, various solutions  
of organic solvents capable of dissolving the binding  
component, and aqueous solutions of alkali, such as sodium  
hydroxide, for example, or an aqueous solution of an acid  
may also be used. These fluids are pressurized and are  
15 jetted from orifices having a small aperture diameter or  
from slits having a small gap in the form of high speed  
columnar streams or curtain-like streams.

There is no limitation, in particular, to the shape of the  
20 jet nozzle main body, but a transverse nozzle having a  
number of orifices having a diameter of about 0.01 to  
0.5 mm that are aligned with narrow gaps between, in a line  
or in a plurality of lines can be conveniently used to  
obtain a fiber sheet having less surface unevenness and  
25 uniform properties.

The gap between the adjacent orifices is preferably from  
about 0.2 to 5 mm in terms of the distance between the  
centers of these orifices. If the gap is smaller than about  
30 0.2 mm, machining of the orifices becomes difficult and the  
high speed fluid jet streams are likely to come into  
contact with streams from adjacent orifices. If the gap is  
greater than about 5 mm, the surface treatment of the fiber  
sheet must be carried out many times.

35

The pressure applied to the fluid varies with the proper-  
ties of the non-woven fabric and can be freely selected

1 within the range of about 5 to 300 kg/cm<sup>2</sup>. The high speed  
fluid jet streams may contact the fiber sheet several  
times, the pressure for each jet may be varied or the  
nozzle or non-woven fabric may be oscillated during jetting  
5 to optimize fabric properties.

The binding components used for bundling and temporarily  
bonding the ultrafine fibers are preferably those which can  
be easily removed by water for industrial economy. Examples  
10 of such components are starch, polyvinyl alcohol, methyl-  
cellulose, carboxymethylcellulose and the like. Synthetic  
and natural pastes and adhesives that can be dissolved by  
solvents can also be used. Examples of such pastes and  
adhesives are vinyl type latex, polybutadiene type ad-  
15 hesives, polyurethane type adhesives, polyester type  
adhesives, polyamide type adhesives, and so forth.

In the production of the entangled non-woven fabric in  
accordance with the present invention, it is not necessary  
20 to use wholly ultrafine fibers and a combined use of other  
fibers may be permitted in so far as it does not diverge  
from the object of the present invention. It is also  
possible to incorporate resin binder as well.

25 The grained sheet in accordance with the present invention  
may be produced by the following method. The ultrafine  
fiber formable fibers are first produced by use of a  
spinning machine such as one disclosed in Japanese Patent  
Publication No. 18369/1969, for example, and are then  
30 converted into staple fiber, and the resulting staple  
fibers are passed through a card and a cross lapper to form  
a web. The web is needle-punched to entangle the ultrafine  
fiber formable fibers and to form a fiber sheet. Alter-  
natively, after the ultrafine fiber formable fibers are  
35 spun, they are subsequently stretched and are randomly  
placed on a metal net. The resulting web is needle-punched  
in the same way as above to obtain the fiber sheet. Still

1 alternatively, the ultrafine fiber formable fibers are  
placed on a non-woven fabric, woven fabric or knitted  
fabric consisting of ordinary fibers or another kind of  
ultrafine fiber formable fibers and are inseparably en-  
5 tangled to form a fiber sheet. The fiber sheet thus  
obtained is treated with high speed fluid jet streams to  
branch the ultrafine fiber formable fibers into ultrafine  
fibers to fine bundles of ultrafine fibers and to simul-  
taneously entangle the fibers and their bundles. The  
10 treating method used for the production of the entangled  
non-woven fabric of the present invention described above  
can also be used for this high speed fluid jet stream  
treatment. The non-woven fabric of the present invention  
described hereinabove can also be preferably used for  
15 producing the grained sheet of the present invention.

If the ultrafine fiber formable fibers used are of the type  
which can be modified to ultrafine fiber bundles when part  
of the components are dissolved and removed, the dissolving  
20 and removing step is thereafter applied depending on the  
intended application. If necessary, the sheet is wet-  
coagulated or dry-coagulated by impregnating the sheet with  
a solution or dispersion of a polyurethane elastomer or the  
like. In this instance, part of the fiber components may be  
25 dissolved and removed before the high speed fluid jet  
stream treatment. Since the ultrafine fiber formable fibers  
of the sheet are modified into bundles of ultrafine fibers  
as part of the components are dissolved and removed, the  
fibers can be highly branched and entangled easily by a low  
30 fluid pressure. The high speed fluid jet stream treatment  
may be effected both before and after the dissolving and  
removing treatment of the component.

It is further possible to interpose the step of applying  
35 the resin between the high speed fluid jet streams treat-  
ment and the dissolving and removing step of the component.  
In this case, it is necessary that the resin should not be

- 1 dissolved by the solvent used for dissolving and removing  
the component. Since the component is thus removed, the  
gaps are defined between the ultrafine fiber bundles and  
the resin of the resulting fiber sheet and promote freedom  
5 of mutual movement of the fibers. Hence, this is a pre-  
ferred method for providing the resulting sheet with  
excellent hand characteristics, such as flexibility and  
suppleness.
- 10 On the other hand, application of the high speed fluid jet  
stream treatment after the application of the resin is not  
preferable because, if the deposition quantity of the resin  
is too great, the fibers are restricted by the resin and  
consequently, branching and entanglement of the fibers and  
15 their bundles cannot readily be effected. Thereafter, the  
solution or dispersion of the aforementioned grain resin is  
applied to the layer of the fiber sheet in which ultrafine  
fibers to fine bundles of ultrafine fibers are entangled  
with one another, by suitable methods such as reverse roll  
20 coating, gravure coating, knife coating, slit coating,  
spray coating and the like, is then wet-coagulated or  
dry-coagulated, is put on the surface of a roller or the  
surface of the plane sheet and is thereafter pressed and,  
if necessary, heated so as to integrate the fibers with  
25 the resin and to simultaneously flatten the surface.

In this case, it is preferred to make the surface of the  
fiber sheet flat by heat-pressing the fiber sheet before  
the application of the grain resin. The use of an embossing  
30 roller or a sheet having a grain pattern is preferred  
because integration, flattening and application of the  
grain pattern can be simultaneously conducted. If  
necessary, depending on the final application, coating with  
a finishing agent, dyeing, crumpling and the like may be  
35 carried out.

1 In using the grained sheet of the present invention for  
apparel, the following method is preferably employed if  
flexibility and soft touch are particularly necessary. A  
substance that can degrade or plasticize the binding  
5 component of the ultrafine fiber formable fibers is applied  
to the fiber sheet consisting of such ultrafine fiber  
formable fibers and high speed fluid jet stream treatment  
is then carried out. The resulting fiber sheet is heat-  
pressed so as to make the surface to which the high speed  
10 fluid jet stream treatment is applied smooth. Next, this  
surface is coated with a resin solution of a polyurethane  
elastomer or the like and is solidified in such a manner  
that part of the resin penetrates into the sheet and resin  
remains as a thin layer on the sheet surface. A grain  
15 pattern is then applied using an embossing roller on the  
sheet surface, if necessary, and after the binding com-  
ponent is dissolved and removed, finishing treatments, such  
as dyeing, application of softening agents, crumpling and  
the like are carried out.

20 The entangled non-woven fabric in accordance with the  
present invention has high flexibility, retains its shape  
and has particularly high shape retention when wet such as  
when the fabric contains a liquid, such as water. Because  
25 of these properties, the non-woven fabric can be suitably  
used for cloths, towels, various filters, materials such as  
grips, various covers, substrates for synthetic leathers,  
polishing cloths for furniture, automobiles or glass,  
polishing pads, cassette tape pads, wiping cloths, and so  
30 forth.

The grained sheet in accordance with the present invention  
has excellent hand characteristics such as flexibility and  
suppleness, smooth surface touch, high flexibility resist-  
35 ance, high shearing fatigue resistance and high scratch and  
scuff resistance. For these properties, the grained sheet  
can be suitably used as grained synthetic leather for

- 1 apparel, shoe uppers, handbags, bags, belts, gloves,  
surface leather of balls and the like.

The following examples are intended to further clarify the  
5 present invention but are in no way limitative. In the  
examples which follow, the terms "part or parts" and "%" refer to the "part or parts by weight" and "% by weight" unless otherwise stipulated. The value of the average distance of the fiber entangling points is a mean value of  
10 100 measured values.

Example 1

- 15 Islands-in-a-sea type fibers (4.5 denier) consisting of 70 parts nylon 6 as the binding component (sea component) and 30 parts polyethylene terephthalate containing 0.1% of titanium oxide as the ultrafine fiber component (islands component) were treated with formic acid to continuously  
20 dissolve and remove nylon 6. The remaining ultrafine polyethylene terephthalate fibers consisted of 36 filaments of about 0.038 denier. The fibers were then bonded with each other to form fiber bundles by use of a paste consisting of a partial saponified polyvinyl alcohol. A large  
25 number of fiber bundles were gathered in a tow, were then passed through a stuffer box type crimper to apply crimp of about 12 crimps/inch without heating and were subsequently cut to form 51 mm staple fibers. The staple fibers were passed through a random webber for random webbing and were  
30 needle-punched at a rate of 2,500 needles/cm<sup>2</sup> to provide a non-woven fabric having an apparent density of 0.19 g/cm<sup>3</sup>.

- After being pressed by a heated roller to achieve an  
35 apparent density of 0.21 g/cm<sup>3</sup>, the non-woven fabric was placed on a 100 mesh metal net which was being moved and water pressurized to 70 kg/cm<sup>2</sup> was jetted from a nozzle

- 1 having a large number of aligned small apertures and a  
large number of the columnar streams of the water were  
jetted to the surface of the non-woven fabric. The treat-  
ment was repeated three times for each surface of the  
5 non-woven fabric in order to effect dissolution of the  
paste and, at the same time, branching and entanglement of  
the fibers. The fabric was then dried. The resulting dried  
entangled non-woven fabric consisted of ultrafine fibers  
branching from the portions of about 1/4 thickness from  
10 both surfaces and of bundles of such ultrafine fibers and  
had a densely entangled structure. The entangled non-woven  
fabric had pleasant touch and was soft and not easily  
deformed.
- 15 For comparative purpose, the non-woven fabric having an  
apparent density of  $0.19 \text{ g/cm}^3$ , which was obtained by  
only needle punching, was dipped into hot water, whereupon  
the paste was dissolved and along therewith, the non-woven  
fabric became easily deformable and difficult to handle.
- 20 Accordingly, the non-woven fabric was placed on a metal  
net, was left standing still in hot water for a day and  
night to dissolve and remove the paste, and was dried. The  
resulting non-woven fabric had a structure in which the  
ultrafine fiber bundles were loosely entangled with one  
25 another in bundle form. Though the non-woven fabric was  
soft, it was remarkably deformed and its surface was  
unsightly fluffed when it was slightly pulled or rubbed.

30 Example 2

Filaments, each consisting of 16 multi-hollow type ultra-  
fine fibers of nylon 6 of 0.5 denier, were bonded together  
by a carboxymethylcellulose paste to form a bonded fiber  
35 bundle. The crimped fibers were cut to a length of about  
38 mm and were thereafter passed through a card and a cross  
lapper to obtain a web. The web was needle-punched at a



1 rate of 1500 needles/cm<sup>2</sup> to obtain a non-woven fabric.  
The resulting non-woven fabric had an apparent density of  
0.15 g/cm<sup>3</sup>. When it was subjected to treatment with water  
jet streams under the same conditions as in Example 1,  
5 there was obtained an entangled non-woven fabric which was  
soft and had excellent shape retention. Since this en-  
tangled non-woven fabric had extremely high water absorbing  
characteristics, it was most suitable for various kinds of  
cloths and towels.

10

### Example 3

Islands-in-a-sea type fibers of 3.5 denier, having a  
15 composition consisting of 30 parts of a vinyl type polymer,  
obtained by copolymerizing 20 parts of 2-ethylhexylacrylate  
and 80 parts of styrene, as the binding component (sea  
component), and 70 parts of polyethylene terephthalate as  
the ultrafine fiber component (islands component), and  
20 containing 16 ultrafine fibers in one filament. The fibers  
were crimped and cut to form a web in the same way as in  
Example 1, followed by needle-punching at a rate of 1500  
needles/cm<sup>2</sup> to provide a non-woven fabric(1). Alterna-  
tively, 3.5 denier specific islands-in-a-sea type fibers  
25 having a composition consisting of 45 parts of a mixture of  
95 parts of polystyrene and 5 parts of polyethylene glycol,  
as the binding component (sea component), and 55 parts of  
polyethylene terephthalate as the extra-ultrafine fibers  
component (islands component) and containing 16 island  
30 component groups in one filament with each island com-  
ponent group containing therein a large number of the  
extra-ultrafine fibers, were crimped and were cut to 38 mm  
staple fibers. After the resulting web was passed through a  
card and a cross lapper, it was sprinkled over the non-  
35 woven fabric(1) described above for lamination.

1 Subsequently, needle-punching was effected at a rate of  
1500 needles/cm<sup>2</sup> from the web side so as to integrate the  
web with the non-woven fabric(1). The non-woven fabric thus  
integrated had an apparent density of 0.20 g/cm<sup>3</sup>. Water  
5 which was pressurized to 100 kg/cm<sup>2</sup> was jetted to the web  
side of this integrated non-woven fabric while it was being  
moved, using the same nozzle as that of Example 1 and this  
treatment was repeated four times. Thus, the fibers of the  
laminated web portion were thinly branched and were densely  
10 entangled with one another. Next, the non-woven fabric was  
dipped into trichloroethylene with dipping and wringing  
repeated so as to extract and remove substantially com-  
pletely the binding component. Drying was then effected to  
evaporate and remove the remaining trichloroethylene. The  
15 entangled non-woven fabric thus obtained had extremely soft  
touch and was shape retentive.

#### Example 4

20

Staple fibers, 51 mm long and 4.0 denier, of islands-in-  
a-sea type fibers disclosed in Japanese Patent Publication  
No. 37648/1972 were utilized. The fibers had a composition  
consisting of 60 parts of vinyl type polymer obtained by  
25 copolymerizing 20 parts of 2-ethylhexylacrylate and 80  
parts of styrene, as the binding component (sea component),  
and 40 parts of nylon 6 as the extra-ultrafine fiber  
component (islands component) and containing 16 island  
component groups in one filament with each island component  
30 group containing therein a large number of the extra-  
ultrafine fibers. The staple fibers were passed through a  
card and a cross lapper to form a web. The web was needle-  
punched using needles having a hook number of 1, so as to  
entangle the island-in-a-sea type fibers and to produce  
35 non-woven fabric (A). The non-woven fabric had a weight per  
unit area of 405 g/m<sup>2</sup> and an apparent density of 0.20  
g/cm<sup>3</sup>.

1 Water which was pressurized to  $100 \text{ kg/cm}^2$  was jetted and brought into contact at a high speed with the surface of the non-woven fabric (A) while it was being moved, from a nozzle having a line of apertures having a diameter of  
5 0.1 mm and a distance pitch of 0.6 mm between the centers of the apertures. The non-woven fabric was treated five times and ten times under the same conditions, respectively. Next, the pressure of the water was reduced down to  $50 \text{ kg/cm}^2$  and the same treatment was applied once to the  
10 non-woven fabrics while oscillating the nozzle, thereby forming non-woven fabrics (B) and (C), respectively. Each of the resulting non-woven fabrics (B) and (C) had a fiber structure in which the islands-in-a-sea type fibers of the surface layer were branched into ultrafine fibers and into  
15 fine bundles of ultrafine fibers and were densely entangled with one another.

Each of the non-woven fabrics (A), (B) and (C) was then impregnated with a 7% dimethylformamide solution of poly-  
20 urethane prepared by chain-extending a prepolymer between a mixed diol consisting of polyethylene adipate diol and polybutylene adipate diol and p,p'-diphenylmethane diisocyanate using ethylene glycol. After the solution adhering to the surface was removed by a scraper, each non-woven  
25 fabric was introduced into water and the polyurethane was coagulated. Thereafter, the non-woven fabric was sufficiently washed in hot water at  $80^\circ\text{C}$  to remove the dimethylformamide. After being dried, the non-woven fabric was repeatedly dipped into trichloroethylene and squeezed  
30 to extract the vinyl type polymer sea component of the fibers. After the resin was extracted and removed substantially completely, the non-woven fabric was dried to evaporate and remove the remaining trichloroethylene.

35 The sheets obtained from the non-woven fabrics (B) and (C) were devoid of unevenness and were extremely smooth on the surface to which the water stream treatment was applied but

1 the sheet obtained from non-woven fabric (A) was found to  
have unevenness extending along the ultrafine fiber bundles  
and had low smoothness. Next, a solution which was prepared  
by adding a pigment to a 10% solution of polyurethane,  
5 which had the same composition as that used for impregna-  
tion but had considerably higher hardness, was applied to  
the surface of each sheet by use of a gravure coater. The  
sheet was then dried. The treatment using a gravure coater  
and the treatment of drying were repeated twice. There-  
10 after, it was passed through a hot embossing roller for  
pressing to apply a leather-like grain pattern. Thereafter,  
the sheet was dyed at a normal pressure using a circu-  
lating-liquor dyeing machine and was finished in a  
customary manner.

15

The grained sheets obtained from the non-woven fabrics (B)  
and (C) had a smooth surface along the grain pattern, were  
soft and had integral hand characteristics such as flex-  
ibility and suppleness. On the other hand, the sheet  
20 obtained from the non-woven fabric (A) exhibited unevenness  
having vein-like lines extending along the ultrafine fiber  
bundles and dyeing cracks that extended locally along the  
ultrafine fiber bundles. The ultrafine fibers appeared at  
the surface of these cracks.

25

The polyurethane and finishing agent applied to these  
grained sheets were extracted and removed by a solvent and  
the distance between the fiber entangling points was  
measured. The average distance between the fiber entangling  
30 points was 361 microns for the sheet prepared from non-  
woven fabric (A), 193 microns for the sheet prepared from  
non-woven fabric (B) and 77 microns for the sheet prepared  
from non-woven fabric (C).

35

The flexibility resistance, shearing fatigue resistance and  
scratch and scuff resistance of these grained sheets were  
measured according to the following methods:

## 1 (1) Flexibility resistance:

The degree of damage to the grained surface was judged in accordance with JIS (Japanese Industrial Standard) K 6545-1970.

5

## (2) Shearing fatigue resistance:

A 3 cm-wide rectangular testpiece was held by clamps having a clamp gap of 2 cm and stretched by moving one of the clamps parallel to another clamp until a stretch ratio of 25% is reached, then the clamp was moved to the opposite position. This procedure was repeated at a speed of 250 times/min. The degree of damage to the grained surface after 10,000 cycles was judged in accordance with the judging standard described in Item (1) above.

15

## (3) Scratch and scuff resistance:

The grained surface was scratched by a needle of 1 mm diameter with a 500 g load using a Clemens scratch tester. The degree of scratch and scuff resistance was judged by the number of scratches required to develop visible damage on the grained surface.

20

The results are set forth in Table I.

25

Table I

30	Non-woven fabric used	Flexibility resistance	Shearing fatigue resistance	Scratch and scuff resistance
		(1)	(2)	(3)
35	(A)	class 2	class 3	once
	(B)	class 4	class 5	4 times
	(C)	class 5	class 5	4 times

- 1 The test results in Table I demonstrate that the grained  
sheets produced using non-woven fabrics (B) and (C) of the  
present invention were superior to the sheet using non-  
woven fabric (A) in flexibility resistance, shearing  
5 fatigue resistance and scratch and scuff resistance.

Example 5

- 10 A non-woven fabric (A) as prepared in Example 4, was dipped  
into a 5% aqueous solution of polyvinyl alcohol heated to  
95°C in order to effect impregnation of the polyvinyl  
alcohol and at the same time to cause shrinkage of the  
non-woven fabric. The non-woven fabric was dried to remove  
15 moisture. Thereafter, the non-woven fabric was repeatedly  
dipped into trichloroethylene and squeezed to extract and  
remove the vinyl type polymer sea component of the fiber,  
followed by drying of the non-woven fabric. The resulting  
non-woven fabric was one in which the ultrafine fibers were  
20 entangled with one another substantially in the form of  
bundles. Water that was pressurized to 50 kg/cm<sup>2</sup> was  
jetted at high speed to both surfaces of the non-woven  
fabric using the same nozzle as used in Example 4, and the  
treatment was repeated three times for each surface at the  
25 same conditions so as to dissolve the polyvinyl alcohol and  
to simultaneously branch and entangle the fibers. The final  
treatment for each surface was carried out with oscillation  
of the nozzle. After the polyvinyl alcohol was removed, the  
non-woven fabric was pressed through a mangle while wet,  
30 and was thereafter dried.

The surface layer of the resulting non-woven fabric had a  
fiber structure in which the original ultrafine fiber  
bundles were branched to a high degree and were densely  
35 entangled with one another. Thereafter, one side of the  
non-woven fabric was buffed using sand paper and a poly-  
urethane solution was applied to the other surface using a

- 1 gravure coater with the rest of the subsequent procedures  
being the same as those in Example 4. There was thus  
obtained a leather-like sheet.
- 5 Although the shape of the resulting grained sheet was  
substantially fixed only by the entanglement of the fibers,  
the sheet had excellent shape retention and its fiber  
structure was highly analogous to that of natural leather.  
The sheet also had high softness and excellent hand charac-  
10 teristics, such as flexibility and suppleness. When bent  
ends of the fabric were gripped by fingers, the sheet  
exhibited round touch and shape, and neither cracking nor  
fluffing occurred when the sheet was strongly rubbed or  
pulled by hand. When a coat was tailored from this sheet,  
15 it was free from paper-like bent creases and had excellent  
appearance.

The polyurethane and finishing agent were removed from the  
grain of this grained sheet using a solvent and the average  
20 distance between fiber entangling points was measured. It  
was found to be 13 microns.

#### Example 6

- 25 Islands-in-a-sea type fibers of 3.8 denier and 51 mm long  
having a composition consisting of 45 parts of a mixture of  
95 parts of polystyrene and 5 parts of polyethylene glycol,  
as the binding component (sea component), and 55 parts of  
30 polyethylene terephthalate as the ultrafine fibers com-  
ponent (islands component) and containing 16 ultrafine  
fibers in one filament were used to produce a non-woven  
fabric in the same way as in Example 4. The non-woven  
fabric had a weight of  $540 \text{ g/m}^2$  and a thickness of  
35 2.8 mm. Columnar streams of water that were pressurized to  
 $70 \text{ kg/cm}^2$  were jetted to one surface of the non-woven  
fabric while it was being moved, using the same nozzle as

- 1 used in Example 4 and this treatment was carried out five  
times at the same conditions and twice while the pressure  
was reduced to 30 kg/cm<sup>2</sup>. The non-woven fabric was dipped  
into hot water at 95°C for the shrinkage treatment and  
5 was squeezed by a mangle. The thickness of the resulting  
entangled non-woven sheet was reduced to about 1.8 mm and  
the layer of about 1/4 of the total thickness from the  
water jet stream treatment surface had a fiber structure in  
which ultrafine fibers of an average size of about 0.15  
10 denier were branched and the fine bundles of ultrafine  
fibers were very densely entangled with one another, and  
the surface of the non-woven fabric had extremely little  
unevenness.
- 15 Using the same impregnation solution comprising a 10%  
polyurethane solution as used in Example 4, the procedures  
of impregnation, coagulation, washing with water and drying  
were carried out in the same way as in Example 4. Next,  
polystyrene and polyethylene glycol were dissolved and  
20 removed using trichloroethylene. After the non-woven fabric  
was sliced to a thickness of 1.1 mm, a coating prepared by  
adding carbon black and dyes to the polyurethane solution  
was applied to the surface layer which was subjected to the  
water jet stream treatment, using a gravure coater. After  
25 the sheet was dried and pressed for integration to produce  
a composite structure, grain patterning of the composite  
structure was effected. The opposite surface was buffed to  
fluff the ultrafine fibers. Next using disperse dyes, the  
sheet was dyed at a temperature of 120°C and was then  
30 finished in a customary manner. The resulting grained sheet  
had less repulsive feel but had integral hand character-  
istics such as flexibility and suppleness, had fluff of  
relatively long ultrafine fibers on one surface and a  
grained surface of high quality appearance on the other  
35 surface.



1 When the resulting sheet was used as shoe leather, it  
provided shoes having a smooth surface which was devoid of  
so-called "orange-peel" that unavoidably occurs at the  
toe-end of conventional synthetic leather shoes. In com-  
5 parison with conventional polyurethane-coated shoes, the  
shoes of this Example were extremely resistant to  
scratching.

After the polyurethane and finishing agent were removed  
10 from the grain of the grained sheet, the average distance  
between the fiber entangling points was measured. It was  
found to be 98 microns.

15 Example 7

Specific islands-in-a-sea type fibers consisting of poly-  
ethylene terephthalate as the island component and a  
mixture of polystyrene and polyethylene glycol (molecular  
20 weight 20,000) as the sea component (island/sea weight  
ratio = 60/40) and having cross-section in which 16  
island-in-a-sea type structures, in each of which 8 islands  
were present in a sea component, were encompassed by one  
sea component of polystyrene, were spun using an islands-  
25 in-a-sea type fiber spinning die disclosed in Japanese  
Patent Laid-Open No. 125718/1979. The island/total sea  
ratio of the fibers was 48/52. The yarns thus obtained were  
stretched to 2.5 times the original length, crimped and cut  
to provide 3.8 denier, 51 mm long staple fibers. Each  
30 island component was an ultrafine fiber of 0.014 denier.  
The staple fibers were then passed through the steps of  
opening, carding, cross lapping and needle punching to  
provide a non-woven fabric. A columnar stream of the water  
pressurized to 150 kg/cm<sup>2</sup> was jetted to one surface of  
35 the non-woven fabric while it was being moved, from a jet  
nozzle having apertures having a 0.1 mm diameter and  
arranged in a line with 0.6 mm gaps therebetween with

1 oscillating of the nozzle. This treatment was repeated  
three times and the non-woven fabric was then dried.

Next, an 8% dimethylformamide solution of a polyester type  
6 polyurethane was made to permeate, for impregnation, from  
the side of the non-woven fabric to which the water stream  
was not applied. After wet coagulation with water, the  
non-woven fabric was dried. The resulting sheet was pressed  
by a hot roller so as to smooth the surface which was  
10 subjected to the treatment with the water jet stream. A  
two-pack type polyurethane solution was then applied to the  
smoothed surface of the sheet using a gravure coater and  
the sheet was then dried. The deposition quantity of this  
two-pack type polyurethane was about  $3 \text{ g/m}^2$ . After  
15 curing, the surface of the sheet coated with the two-  
component type polyurethane was embossed at  $160^\circ\text{C}$  using  
an embossing roller having a leather-like grain pattern.

Thereafter, the sheet was treated with trichloroethylene to  
20 remove the sea component of the multi-component fibers.  
Then, the back of the sheet was buffed by 150 mesh sand  
paper to fluff the surface and a polyurethane type finish-  
ing agent containing a pigment was applied to the grain in  
a quantity of  $2 \text{ g/m}^2$  using a gravure coater and was then  
25 dyed at  $120^\circ\text{C}$  for one hour using a high temperature  
dyeing machine while crumpling the sheet. The resulting  
sheet had grain on one surface and fluff on the other.

The non-woven fabric, after the treatment with the water  
30 jet streams, was examined by a scanning electron micro-  
scope, and the surface was found to have a fiber structure  
in which the fibrillated ultrafine fibers and the bundles  
were entangled with one another. The distance between the  
fiber entangling points was found to be 85 microns. The  
35 portion below the surface was found to have a structure in  
which a large number of ultrafine fibers were bundled to  
form primary fiber bundles and the layer further below the

1 former was found to have a fiber structure in which a  
plurality of the primary fiber bundles described above were  
further gathered to form an entangled layer consisting  
principally of secondary fiber bundles. One of the surfaces  
5 of the finished sheet had a grain which was composed of the  
fibrillated fibers and the resin encompassing the  
fibrillated fibers and was integrated therewith by emboss-  
ing. It was further observed that the layer of the primary  
fiber bundles and the porous structure of polyurethane were  
10 present below the grain, and the layer of the secondary  
fiber bundles and the porous structure of polyurethane  
further continued below the former down to the back of the  
sheet. The other surface of the sheet was a suede-like  
surface having dense and beautiful fluff and the fluff was  
15 seen continuing from the secondary fiber bundles.

The grain of the sheet of the present invention thus  
obtained had a grain pattern formed by embossing in addi-  
tion to the crumple pattern due to crumpling of the sheet  
20 during dyeing and since they were well mixed, the sheet had  
high quality surface appearance. The fluff surface of the  
sheet exhibited graceful appearance like that of the  
natural suede of deer. Hence, the sheet was suitable as a  
reversible material. Furthermore, the hand characteristics,  
25 such as flexibility and suppleness, were soft and had less  
repulsive property. Though the sheet was strongly rubbed,  
no occurrence of surface cracks was observed.

#### 30 Example 8

4.0 denier, 51 mm long staple fibers of specific islands-  
in-a-sea type fibers having a composition consisting of 60  
parts of a vinyl type polymer obtained by copolymerizing 20  
35 parts of 2-ethylhexylacrylate and 80 parts of styrene as  
the binding component (sea component), and 40 parts of  
nylon 6 as the extra-ultrafine fiber component (islands

1 component) and containing 16 island component groups in one  
filament with each island component group containing  
further a large number of the extra-ultrafine fibers were  
passed through a card and a cross lapper to form a web. The  
5 average size of the extra-ultrafine fibers was about 0.0003  
denier. The web was then needle-punched using needles, each  
having one hook, so as to entangle the specific island-in-  
a-sea type fibers with one another and to produce a non-  
woven fabric. The resulting non-woven fabric had a weight  
10 of about  $450 \text{ g/m}^2$  and an apparent density of  $0.18 \text{ g/cm}^3$ .

The resulting non-woven fabric was then impregnated with a  
10% aqueous dispersion of polyethylene glycol (molecular  
weight 200) monolaurate and was subsequently dried so as to  
15 plasticize the vinyl type polymer sea component. A large  
number of columnar streams of water pressurized to  $100 \text{ kg/cm}^2$   
were jetted once to each surface of the sheet  
using the same jet nozzle as used in Example 7 while the  
nozzle was being oscillated, followed by drying of the  
20 sheet. Next, the sheet was pressed by a hot roller at  
 $150^\circ\text{C}$  to smooth the surface treated with the water  
stream. A 10% solution of polyurethane, to which pigments  
were added, was applied to the surface by a gravure coater  
and after the sheet was dried, the leather-like grain  
25 pattern was applied to the surface of the sheet using a hot  
embossing roller.

Thereafter, the sheet was repeatedly dipped into trichloro-  
ethylene and squeezed to extract and substantially com-  
30 pletely remove the vinyl type polymer sea component of the  
fiber. The sheet was then dried and was dyed with metal-  
complex dyes using a normal-pressure winch dyeing machine.  
After a softening agent was applied, the sheet was crumpled  
and finished.

35

The resulting leather-like sheet had a weight of  
 $220 \text{ g/m}^2$ , an apparent density of  $0.36 \text{ g/cm}^3$ , a clear

- 1 grain pattern and excellent flexibility. When the sheet was strongly crumpled by hand, neither scratching nor damage occurred and the sheet was found to have high flexibility resistance as well as high scratch and scuff resistance.
- 5 After polyurethane was removed from the grain of the grained sheet, the average distance between the fiber entangling points of the constituent fibers was measured. It was found to be 23 microns.

10

Example 9

- 3.8 denier, 38 mm long staple fibers of mixed spun fibers obtained by mixing and spinning two components, which have
- 15 a composition consisting of 45 parts of polystyrene as the binding component, and 55 parts of nylon 6 as the ultrafine fiber component, were passed through a random webber to form a web.

- 20 The average size of the ultrafine fibers was about 0.002 denier. The web was then needle-punched using needles, each having three hooks, so as to entangle the mixed spun fibers with one another and to produce a non-woven fabric. The resulting non-woven fabric had a weight of about  $350 \text{ g/m}^2$
- 25 and an apparent density of  $0.19 \text{ g/cm}^3$ .

The resulting non-woven fabric was shrunk in hot water at  $97^\circ\text{C}$  and then pressed through a mangle to squeeze the excess water and dried.

30

- Water that was pressurized to  $170 \text{ kg/cm}^2$  was jetted at high speed to both surfaces of the non-woven fabric using the same nozzle as used in Example 7 while the nozzle was being oscillated, and the treatment was repeated five times
- 35 for each surface at the same conditions, followed by drying of the sheet. Next, the sheet was pressed by a hot roller at  $150^\circ\text{C}$  to smooth the surface with the rest of the

1 subsequent procedures being the same as those in Example  
8.

The resulting sheet had a weight of  $240 \text{ g/m}^2$ , an apparent  
5 density of  $0.32 \text{ g/cm}^3$ , and shows excellent appearance,  
high softness, and excellent hand characteristics. This  
sheet shows neither cracking nor fluffing even when the  
sheet was strongly rubbed or pulled by hand. After poly-  
urethane was removed from the grain of the grained sheet,  
10 the average distance between the fiber entangling points of  
the constituent fibers was measured to be 46 microns.

#### Example 10

15

2.4 denier, 38 mm long staple fibers of multi-layered  
bicomponent type fibers having a doughnut-like (as shown in  
Fig. 4(e)) cross-section, which have a composition con-  
sisting of 50 parts of polyethylene terephthalate and 50  
20 parts of nylon 66 and have 30 layers, were passed through  
a random webber to form a web. The average size of the  
layers was about 0.08 denier. The web was then needle-  
punched so as to entangle the multi-layered bicomponent  
type fibers with one another. The resulting needle-punched  
25 sheet had a weight of about  $460 \text{ g/m}^2$  and an apparent  
density of  $0.17 \text{ g/cm}^3$ .

The resulting needle-punched sheet was shrunk in hot water  
at  $97^\circ\text{C}$  and then pressed through a mangle to squeeze  
30 excess water and dried.

Columnar streams of water pressurized to  $150 \text{ kg/cm}^2$  were  
jetted to one surface of the needle-punched sheet while  
moving the sheet and oscillating the nozzle. The jet nozzle  
35 had orifices having a 0.2 mm diameter and arranged in a  
line with 1.9 mm gaps therebetween. This treatment was  
repeated 15 times. After drying, the sheet was pressed by a

1 hot roller at 150°C to smooth the surface treated with  
the water streams.

Using an impregnation solution which was prepared by adding  
5 pigments to an 8% solution of polyurethane, the procedures  
of impregnation, coagulation, washing with water and drying  
were carried out in the same way as in Example 4.

A two-pack type polyurethane solution containing pigments  
10 was then applied to the smoothed surface of the sheet using  
a reverse roll coater and then dried. The deposition  
quantity of this two-pack type polyurethane was about  
5 g/m<sup>2</sup>.

15 Next, a polyurethane solution containing carbon black and  
dyes was applied, using a gravure coater, to the surface  
which was treated with the reverse roll coater. After  
drying and pressing the sheet to produce a dense composite  
structure, grain patterning of the composite structure was  
20 effected. Then the sheet was crumpled.

The resulting grained sheet had integral hand character-  
istics and a surface of high quality appearance.

25 When the resulting sheet was used as upper leather of  
soccer shoes, the shoes show excellent resistance to  
scratching.

The non-woven fabric, after the treatment with the water  
30 jet streams, was examined by a scanning electron micro-  
scope, and the surface was found to have a fiber structure  
in which the fibrillated ultrafine fibers and the bundles  
were entangled with one another. The distance between the  
fiber entangling points was found to be 124 microns.

35

1 Example 11

Islands-in-a-sea type fibers of 3.8 denier, having a composition consisting of 50 parts of polyethylene terephthalate as the ultrafine fiber component (islands component) and 50 parts of the binding component (sea component) consisting of 45 parts of polystyrene and 5 parts of polyethyleneetherglycol of a molecular weight of 20,000, and containing 16 ultrafine fibers in one filament, were crimped and cut to a length of about 51 mm, and were thereafter passed through a card and a cross lapper to obtain a web. The web was needle-punched to obtain a non-woven fibrous sheet having a thickness of about 1.0 mm and a weight of about  $190 \text{ g/m}^2$ . The non-woven web was then needle-punched to form a non-woven fibrous sheet having a thickness of about 3.0 mm and a weight of about  $540 \text{ g/m}^2$ .

Water which was pressurized to  $110 \text{ kg/cm}^2$  was jetted and brought into contact at a high speed to both surfaces of the non-woven fibrous sheet from a nozzle having a line of apertures having a diameter of 0.2 mm and a distance pitch of 1.5 mm between the centers of the apertures, while the nozzle was being oscillated, and the treatment was repeated five times for each surface at the same conditions.

The resulting non-woven fibrous sheet was examined by a scanning electron microscope, the fibrillated ultrafine fibers were entangled with one another, especially at near the surfaces. The non-woven fibrous sheet, also, had a good suppleness and an excellent shape retention without dissolving the binding component.

35 Example 12

4.0 denier, 51 mm long staple fibers of mixed spun fibers obtained by mixing and spinning two components which have a



- 1 composition consisting of 50 parts of nylon 6 as the  
ultrafine fiber component, and 50 parts of the binding  
component comprising 40 parts of copolymer of 2-ethyl-  
hexylacrylate/styrene (20/80) and 10 parts of polyethylene-  
5 etherglycol of a molecular weight 50,000 were passed  
through an opener, a card and a cross lapper to form a web.  
The web was needle-punched to obtain a needle-punched sheet  
having a thickness of about 3.0 mm and a weight of about  
540 g/m<sup>2</sup>.
- 10 Water which was pressurized to 100 kg/cm<sup>2</sup> was jetted to  
the surface of the needle-punched sheet from a nozzle  
having a line of apertures of a 0.2 mm diameter and 1.5 mm  
distance pitch, while the nozzle was being oscillated. The  
15 sheet was treated 5 times for each surface at the same  
conditions.
- The jetted sheet was examined by a scanning electron  
microscope, and it was found that most of the binding  
20 components were removed, and the resulting ultrafine fiber  
bundles consisting of ultrafine fibers of about 0.009  
denier were highly fibrillated and the fibrillated ultra-  
fine fibers were densely entangled with one another,  
especially at near the surfaces. The jetted sheet was then  
25 impregnated with a 10% of polyurethane emulsion and was  
dried. Thereafter the sheet was dipped in perchloroethylene  
and dried. The remaining binding component was easily  
removed. A leather-like grain pattern was applied to one  
surface of the dried sheet using a hot embossing roller.  
30 The sheet was then dyed in red. The dyed sheet showed  
extremely dense and smooth surface like that of natural  
grain leather. Moreover, it had excellent supple touch and  
flexibility.

1 Claims:

1. An entangled non-woven fabric comprising a portion (A) comprised of ultrafine fiber bundles, the ultrafine fibers  
5 of said bundles having a size not greater than about 0.5 denier, said fiber bundles of said portion (A) being entangled with one another; and  
a portion (B) branching from said portion (A), said portion (B) comprising either ultrafine fibers or fine bundles of  
10 ultrafine fibers or both, each branching from said ultrafine fiber bundles (A), said fine bundles of portion (B) having a size less than said bundles of portion (A);  
the ultrafine fibers of said portion (B) being entangled with one another;  
15 said portions (A) and (B) being nonuniformly distributed in the direction of fabric thickness.

2. The entangled non-woven fabric as defined in claim 1,  
20 wherein said portion (B) is nonuniformly distributed along one or both surface portions of the fabric.

3. The entangled non-woven fabric as defined in claim 1 or claim 2,  
25 wherein said ultrafine fibers forming said portions (A) and (B) are substantially continuous through portions (A) and (B).

4. The entangled non-woven fabric as defined in any one of  
30 the claims 1 to 3,  
wherein the degree of branching changes continuously around the boundary portion between said portions (A) and (B).

5. The entangled non-woven fabric as defined in any one of  
35 the claims 1 to 4,  
wherein said ultrafine fibers are formed from composite fibers selected from the group consisting of multilayered

- 1 bicomponent type fibers, chrysanthemum-like cross-section  
bicomponent fibers, mixed spun multi-component fibers and  
islands-in-a-sea type fibers.
- 5 6. The entangled non-woven fabric as defined in any one of  
the claims 1 to 5,  
wherein said ultrafine fibers are comprised of a polymer  
material selected from the group consisting of nylon 6,  
nylon 66, nylon 12, copolymerized nylon, polyethylene  
10 terephthalate, polybutylene terephthalate, copolymerized  
polyethylene terephthalate, copolymerized polybutylene  
terephthalate, polyethylene, polypropylene, polyurethane,  
polyacrylonitrile, vinyl polymers and combinations thereof.
- 15 7. A method of producing an entangled non-woven fabric  
including a portion comprised of ultrafine fiber bundles  
entangled with one another and a portion comprised of  
ultrafine fibers to fine bundles of ultrafine fibers  
branching from said ultrafine fiber bundles and entangled  
20 with one another,  
said method comprising the steps of:
- (1) forming a fiber entangled sheet by use of fibers  
comprising an ultrafine fiber component and a binding  
component which bonds said ultrafine fiber component,  
25 arranged in the longitudinal direction of the fibers  
in an arbitrary cross-section, said components being  
polymer materials having a different solvent solu-  
bility from each other;
- (2) dissolving and removing said binding component by use  
30 of a solvent which can dissolve only said binding  
component; and
- (3) applying high speed fluid jet streams so as to branch  
and entangle said fibers.
- 35 8. The method of producing an entangled non-woven fabric as  
defined in claim 7,

1 wherein said binding component contains a heterogeneous  
substance.

9. The method of producing an entangled non-woven fabric as  
5 defined in claim 8,  
wherein said heterogeneous substance is polyalkyleneether-  
glycol.

10. The method of producing an entangled non-woven fabric  
10 as defined in claim 9,  
wherein said polyalkyleneetherglycol is polyethyleneether-  
glycol.

11. A grained sheet having on at least one of its surfaces  
15 a grain formed by a composite structure comprising a fiber  
structure composed of ultrafine fibers to fine bundles of  
said ultrafine fibers and having a distance between the  
fiber entangling points of not greater than about 200  
microns, and a resin in the gap portions of said fiber  
20 structure.

12. The grained sheet as defined in claim 11,  
wherein the lower layer of said grain comprises ultrafine  
fiber bundles that are entangled with one another, said  
25 grain comprises ultrafine fibers to fine bundles of ultra-  
fine fibers branching from said ultrafine fiber bundles of  
said lower layer, said fibers in said lower layer and in  
said grain are substantially continuous and the degree of  
branching of said fibers changes continuously around the  
30 boundary portion between said layers.

13. The grained sheet as defined in claim 11 or claim 12,  
wherein the distance between said fiber entangling points  
is not greater than about 100 microns.

35  
14. The grained sheet as defined in any one of the claims  
11 to 13,

1 wherein said ultrafine fibers are not greater than about  
0.2 denier.

15. The grained sheet as defined in any one of the claims  
5 11 to 13,  
wherein said ultrafine fibers are not greater than about  
0.05 denier.

16. The grained sheet as defined in any one of the claims  
10 11 to 15,  
wherein said ultrafine fibers are formed from composite  
fibers selected from the group consisting of multilayered  
bicomponent type fibers, chrysanthemum-like cross-section  
bicomponent fibers, mixed spun multicomponent fibers and  
15 islands-in-a-sea type fibers.

17. The grained sheet as defined in any one of the claims  
11 to 16,  
wherein said ultrafine fibers are comprised of a polymer  
20 material selected from the group consisting of nylon 6,  
nylon 66, nylon 12, copolymerized nylon, polyethylene  
terephthalate, polybutylene terephthalate, copolymerized  
polyethylene terephthalate, copolymerized polybutylene  
terephthalate, polyethylene, polypropylene, polyurethane,  
25 polyacrylonitrile, vinyl polymers and combinations thereof.

18. The grained sheet as defined in any one of the claims  
11 to 17,  
wherein said resin is selected from synthetic and natural  
30 polymer resins.

19. The grained sheet as defined in claim 18,  
wherein said resin is selected from the group consisting of  
polyamide, polyester, polyvinyl chloride, polyacrylate  
35 copolymers, polyurethane, neoprene, styrene/butadiene  
copolymers, acrylonitrile/butadiene copolymers, polyamino

1 acids, polyamino acid/polyurethane copolymers, silicone  
resins and mixtures thereof.

20. The grained sheet as defined in claim 19,  
5 wherein said resin is polyurethane.

21. A method of producing a grained sheet having on at  
least one of its surfaces a grain formed by a fiber  
structure composed of ultrafine fibers to fine bundles of  
10 said ultrafine fibers and having a distance between the  
fiber entangling points of not greater than about 200  
microns, and a resin present in the gap portions of said  
fiber structure,

said method comprising the steps of:

- 15 (1) forming a fiber sheet using fibers selected from  
ultrafine fiber formable fibers and ultrafine fibers;  
(2) applying high speed fluid jet streams to said fiber  
sheet to branch and entangle said fibers; and  
(3) applying at least one kind of resin.

20

22. The method of producing a grained sheet as defined in  
claim 21,  
wherein said ultrafine fiber formable fibers are those  
which have a cross-section in which a plurality of cores  
25 are at least partially bonded by other components.

23. The method of producing a grained sheet as defined in  
claim 21 or claim 22,  
wherein said ultrafine fiber formable fibers are multiple-  
30 component fibers which provide fiber bundles of ultrafine  
fibers not greater than 0.2 denier when at least one of  
their components is dissolved and removed.

24. The method of producing a grained sheet as defined in  
35 claim 23,  
wherein said ultrafine fibers are not greater than  
0.05 denier.

- 1 25. The method of producing a grained sheet as defined in  
any one of the claims 21 to 24,  
wherein said ultrafine fiber formable fibers are those  
which have a fiber structure in which a plurality of  
5 extra-ultrafine fibers are aggregated and bonded together  
by other components to form one ultrafine fiber and a  
plurality of said ultrafine fibers are aggregated and  
bonded by other components to form one fiber.
- 10 26. The method of producing a grained sheet having on at  
least one of its surfaces a grain formed by a fiber  
structure composed of ultrafine fibers to fine bundles of  
said ultrafine fibers and having a distance between the  
fiber entangling points of not greater than about 200  
15 microns, and resin present in the gap portions of said  
fiber structure, as defined in any one of the claims 21 to  
25,  
wherein a step of dissolving and removing part of the  
components of said ultrafine fiber formable fibers by use  
20 of a solvent capable of dissolving said part of the com-  
ponents so as to modify said ultrafine fiber formable  
fibers into a plurality of ultrafine fibers is inserted  
into the production process of said sheet at a suitable  
step.
- 25 27. A method of producing a grained sheet having on at  
least one of its surfaces a grain formed by a fiber  
structure composed of ultrafine fibers to fine bundles of  
said ultrafine fibers and having a distance between the  
30 fiber entangling points of not greater than about 200  
microns, and resin present in the gap portions of said  
fiber structure,  
wherein said entangled non-woven fabric as defined in claim  
1, 2, 3 or 4 is used as the starting material and resin is  
35 applied to at least said portion (B) of said non-woven  
fabric to form the grain.

1 28. The method of producing a grained sheet as defined in  
claim 26,  
wherein said part of components of said ultrafine fiber  
formable fibers contains a heterogeneous substance.

5

29. The method of producing a grained sheet as defined in  
claim 28,  
wherein said heterogeneous substance is polyalkyleneether-  
glycol.

10

30. The method of producing a grained sheet as defined in  
claim 29,  
wherein said polyalkyleneetherglycol is polyethyleneether-  
glycol or copolymer thereof.

15

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30

35



Fig. 1

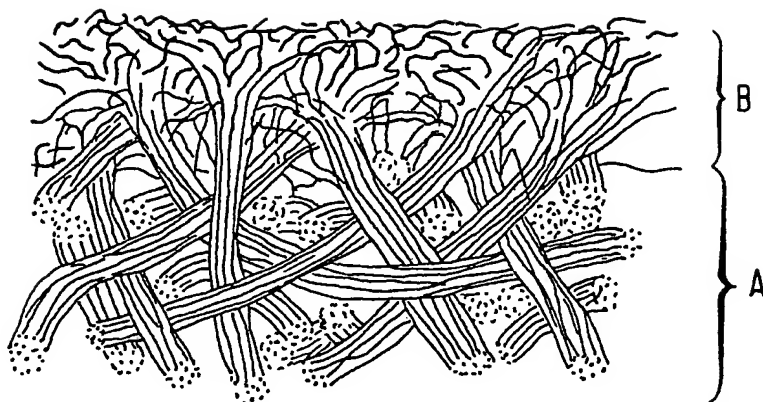


Fig. 2a

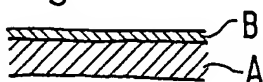


Fig. 2b

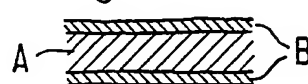


Fig. 2c

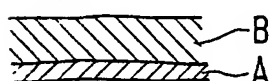


Fig. 2d

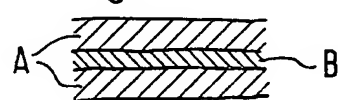


Fig. 2e

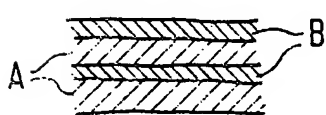


Fig. 2f

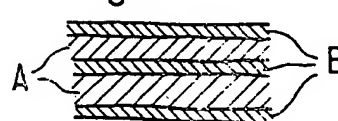


Fig. 2g

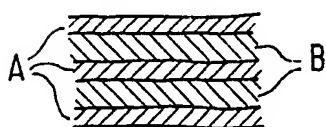


Fig. 3

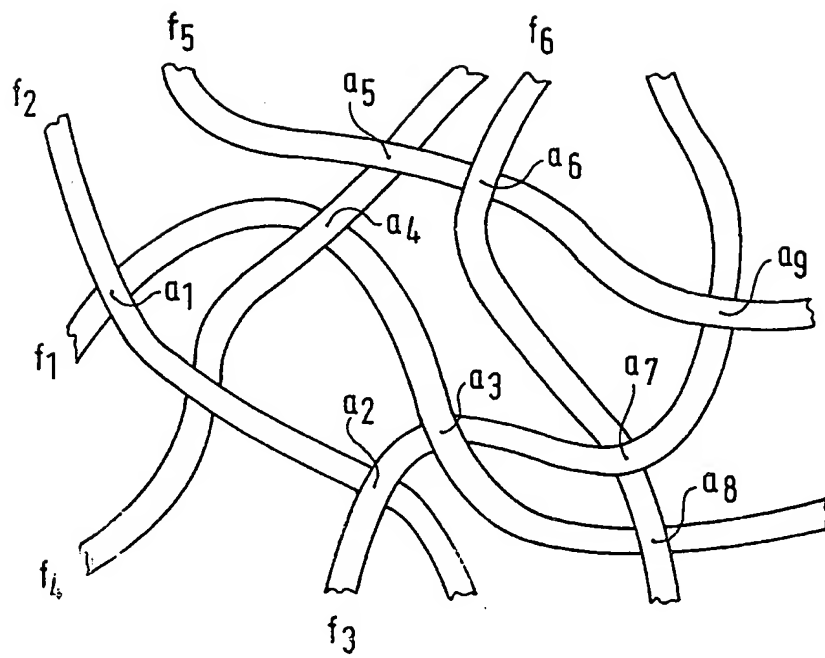


Fig. 4a

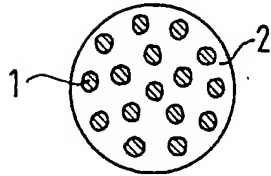


Fig. 4b

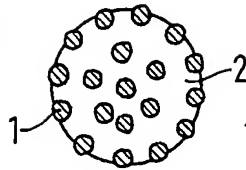


Fig. 4c

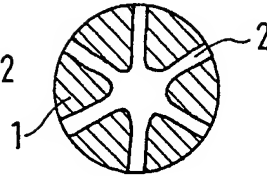


Fig. 4d

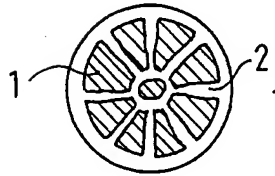


Fig. 4e

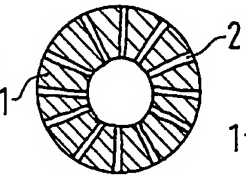


Fig. 4f

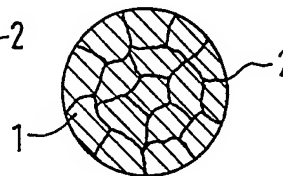


Fig. 4g

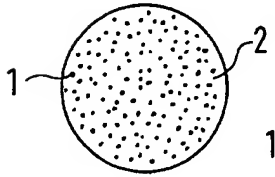


Fig. 4h

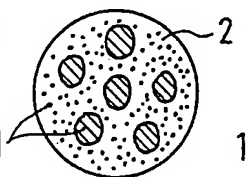


Fig. 4i

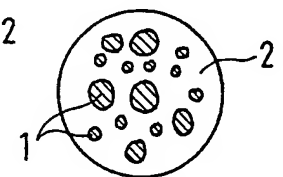


Fig. 4j

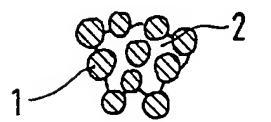


Fig. 4k

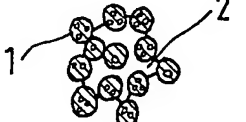


Fig. 4l

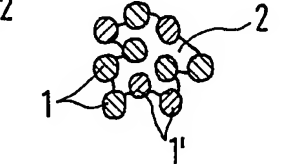


Fig. 4m



Fig. 4n

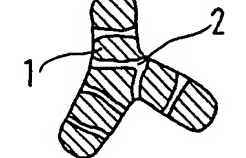


Fig. 4o

